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THE CAUSE OF BANDING IN FISSURE VEINS

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Banding is a feature not uncommonly exhibited by deposits formed by the filling of fissures or other kinds of cavities. It may be due to alternating bands of different minerals of either metallic or non-metallic character, or in other cases it may be caused by successive deposits of the same mineral, the bands of which differ in purity, texture or degree of crystallinity. The bands may also vary in their regularity.

In this paper the several explanations of banding that have been suggested will be briefly outlined and some further causes of this phenomenon will be offered.

Previous Views on Banding

Banding, particularly in fissure veins has been referred to by a number of writers,[1] but their explanations of its origin naturally differ somewhat.

Lindgren[2] states that "Precipitation from complex solutions in open spaces takes place in a certain orderly succession, and the deposits therefore assume a banded texture. . . ."

In a paper referring to the vein filling at Bendigo, Victoria, where quartz is found on ankerite, he remarked that: "It seems difficult to explain these relations by any other theory than that the cavity in the slate was first formed and that it remained open until the coating of ankerite had been deposited. At that time the character of the solutions changed and quartz was deposited."[3]

Whitehead,[4] also in discussing the veins at Cobalt, Ontario, writes: "The solutions, as shown by banding in the veins were changing in composition."

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[1] Posepny, F., *Trans. Amer. Inst. Min. Engrs.*, vol. **23**, p. 197, 1894; Boydell, H. C., *Trans. Inst. Min. Met.*, London, vol. **34**, p. 196, 1924.

[2] Mineral Deposits, 4th ed., p. 168, **1933**.

[3] *Econ. Geol.*, vol. **15**, p. 314, 1920.

[4] *Econ. Geol.*, vol. **15**, p. 124, 1920.

Posepny,[5] observed that crustification was characteristic of cavity filling, and that the solutions were aqueous ones from which the minerals were deposited as crusts on the walls and around foreign objects in the cavities, such as fragments of wall rocks or earlier crusts, producing "crusted kernels" or a "cockade" structure.

"Differential crystallization" in concentrated solutions is the process assigned by Spurr[6] to explain the banding in some veins described in his book. He also refers to "pulsating crystallization" in fissure veins, but the exact manner in which either of these processes operates is not quite clear from the text. Fractional crystallization is scarcely more than mentioned.

The researches of Liesegang in connection with rhythmic precipitation,[7] caused by a reagent diffusing into a gel containing an active solute, and the application of this phenomenon to explain the banding in agates[8] has suggested its use to explain the banding in some ores.[9]

As noted by Lindgren,[10] "diffusing substances may meet and produce uniform or rhythmical replacements, a rhythmical banding . . . ," an explanation which he has applied to certain quartz-chalcedony bands in the ore deposits at Tintic, Utah.[11]

Knopf, in describing the banding of the wood-tin found in the Tertiary rhyolites of Nevada,[12] also suggests that it represents a diffusion effect.

Other causes mentioned are filling of fractures in a sheared vein,[13] and electro-kinetic deposition.[14]

So far as the concentration of the solutions is concerned, there seems to be a general opinion among most writers except Spurr, that they were of dilute character.[15]

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[5] *Trans. Amer. Inst. Min. Engrs.*, vol. **23,** p. 197, 1894.

[6] The Ore Magmas, pp. 142, 524, 690, **1923.**

[7] Geologische Diffusionen, 1913: Review by A. Knopf, *Econ. Geol.*, vol. **8,** p. 812, 1913.

[8] Liesegang, Die Achate, 1915.

[9] Hatscheck, E. and Simon, A. L., *Trans. Inst. Min. and Met.*, London, vol. **21,** pp. 451–480, 1920; Watanabe, M., *Econ. Geol.*, vol. **19,** pp. 497–503, 1924.

[10] Mineral Deposits, 4th ed., p. 177, **1933.**

[11] *Econ. Geol.*, vol. **10,** p. 233, 1915.

[12] *Econ. Geol.*, vol. **11,** p. 652, 1916.

[13] Lindgren, Mineral Deposits, 4th ed., p. 173, **1933.**

[14] Van der Veen, R. W., Mineragraphy and Ore Deposition, p. 96, **1925.**

[15] Boydell, H. C., Operative Causes in Ore Deposition, *Trans. Inst. Min. and Met.*, London, **1927,** p. 36.

Boydell has divided the causes of banding into four groups as follows.[16]

1. Banding by incrustation in open spaces.
2. Banding following lines of shear and fracture.
3. Banding by replacement along shear planes, etc.
4. Banding by processes taking place in gels.

Boydell seems to place special emphasis on the last group, which hardly appears correct for the reason that there is little widespread evidence of colloform structures in fissure veins. A further objection to the acceptance of a general application of this phenomenon to banding in fissure veins is found in the delicate adjustment of concentrations[17] necessary between the incoming reagent and the solute in the gel in order to effect rhythmic deposition. Moreover, there must be the proper combination of reagent and solute to produce a metathetical reaction in the gel.

It seems to the writer that the classification of banded structures suggested by Boydell is incomplete, and he therefore proposes the following:

1. CRUSTIFICATION.
    a. Crystallization from changing solutions which carry essentially one mineral at a time.
    b. Fractional and rhythmic fractional crystallization from complex solutions of either dilute or concentrated character.
    c. Colloidal deposition with alternating colored bands.
    d. Colloidal deposits with bands of adsorbed colored minerals.
    e. Successive bands of the same mineral, having different textures.
    f. Bands of the same mineral of different colors.
    g. Crystalline bands (sometimes of the same mineral) alternating with bands of clay or other colloidal minerals.
    h. Inclusions of colloidal particles or other material forming streaks in the bands of crystalline material.
    i. A combination of two or more of the above.
2. REPLACEMENT.
    a. Along shear or fracture planes.
    b. Around fragments, in part a crustification.
    c. Along bands of clay or colloids.
    d. Along contacts of mineral crusts.
3. REOPENING AND FILLING WHICH MAY BE REPEATED.
    a. By processes under 1.
    b. By crystallization in a fissured non-banded vein, of a concentrated monomineral solution.

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[16] *Trans. Inst. Min. and Met.*, London, vol. **34**, p. 196, 1924.

[17] Bradford, S. C., Adsorptive Stratification in Gels, *Jour. Biochem.*, vol. **10,** pp. 169, 196; vol. **11,** p. 14; vol. **14,** pp. 29 and 474.

CRUSTIFICATION

This structural feature is not uncommon in many filled fissure veins, or even other filled cavities, and has the characteristic appearance shown by Fig. 1. The relation of the bands to the surface from which mineral growth started may be clearly indicated by the lemniscate-like curves of the crusts (Fig. 1), and in addition in the illustration by the variation in size of the grains in the quartz bands.

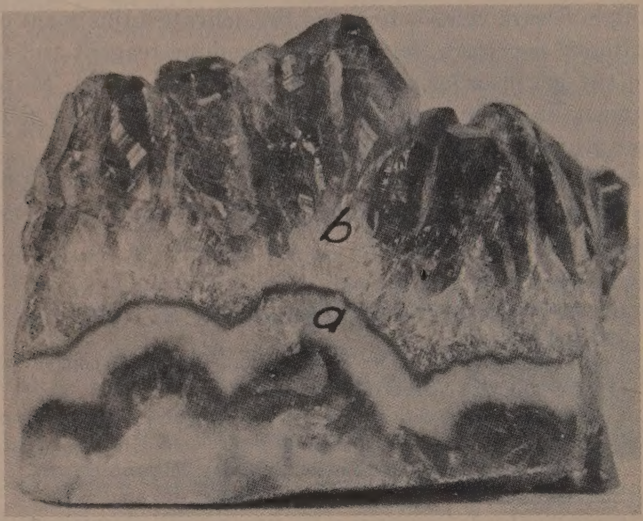

FIG. 1. Banding showing change from chalcedony to amethystine quartz.

It is probably rare that successive mineral crusts are deposited in perfect parallelism for any appreciable distance, because of the initial irregularity of the surface of deposition, or uneven rate of growth of the crystals.

Those crystals or crystal groups that extend farthest into the vein solution are most likely to receive more material from it, owing to the fact that the solution adjacent to the crust is more stagnant, and contains a relatively lower concentration through the crystallization of the solute. For the same reason, projecting portions of the crust would grow faster than the main part, and so assist in increasing the convexity of the bands.

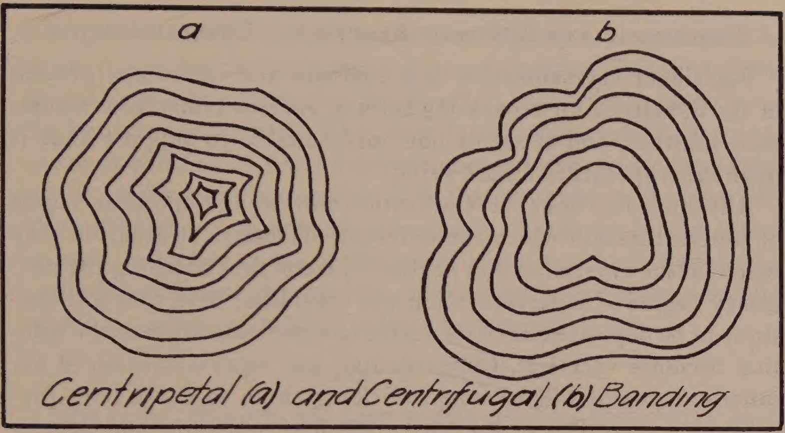

FIG. 2. Diagrammatic illustration of centripetal (*a*), and centrifugal (*b*) types of banding.

Crust accumulating on the walls of a circular opening and growing toward the center develop the lemniscate-like bands shown in Fig. 2, *a*. This may be called *centripetal* banding. Should bands develop from a central point or axis and extend outward, it may be referred to as *centrifugal* banding (Fig. 2, *b*).

Individual bands or crusts may be started either by the accumulation of a layer of colloidal material (Fig. 1, *a*), or by the development of a band of very small closely packed crystals or grains indicating in either case a rapid rate of reprecipitation or crystallization from a supersaturated solution. As the degree of supersaturation diminishes or the rate of cooling decreases, the rate of growth of the crystals decreases.

Furthermore, with decreasing supersaturation, the osmotic pressure becomes less and the conditions are more favorable for the growth of larger crystals.[18]

The bands may thus be terminated by a comb of crystals which on the average are many times larger than those formed earlier (Fig. 1, *b*).

If the concentration or degree of supersaturation is subsequently sufficiently increased, a new band of small crystals will start and cover the larger ones since the osmotic pressure will then be increased sufficiently to permit the growth of smaller crystals in contact with the larger ones.

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[18] Nernst, W., Theoretical Chemistry, p. 762, 1923. Translation by L. W. Cood.

FRACTIONAL AND RHYTHMIC FRACTIONAL CRYSTALLIZATION

Fractional crystallization is a common and important process in the industries for separating salts of various kinds from a common solution, and it seems not unreasonable to suppose that it might also operate in fissure veins.

Rhythmic fractional crystallization will depend upon the degree of supersaturation which the different substances in solution may reach before crystallization begins. The one first reaching the necessary degree of supersaturation will crystallize first, and will continue to be deposited until its degree of supersaturation in the solution becomes very low. Concordantly, the supersaturation of another compound will become sufficiently high to cause it to precipitate or crystallize on the crust of the first compound and thereby separate the solid or solution phases of the first. While the supersaturation of the second compound is being reduced by crystallization, the first may again reach a state of sufficient supersaturation to repeat the cycle and produce rhythmic banding.

It therefore seems possible that such a process may be operative in fissure veins, and account for the alternating bands of non-metallic minerals and sulphides which may be present in magmatic solutions.

Regarding the actual degree of saturation of these solutions we know comparatively little, although some studies by Newhouse on the composition of mineral solutions from liquid inclusions, has indicated that the concentration might be high,[19] and in any event a mineral would not be precipitated until the solution was saturated with respect to it.

It is also possible that more than two minerals may be involved in the process and when any mineral does not crystallize rapidly enough to isolate the solid and solution phases of the one earlier formed the two might crystallize simultaneously.

This process may continue until the solution is completely crystallized or deposition ceases for some other reason.

The width of the bands would probably depend principally on the physico-chemical nature of the substance and solution, the degree of supersaturation to which any of the substances may be raised, the rate of diffusion, and quantity of the solution.

Should there be quartz in both the solution and in the wall rock, the first mineral to crystallize would very likely be quartz since the solution cannot become more than slightly supersaturated because it is in contact with some of its solid phase. This initial crust of quartz is common in fissure veins, and Spurr[20] calls attention to its frequent occurrence. Rhythmic fractional crystallization as a cause of banding in filled fissures appears to be rarely mentioned, but it seems more reasonable than the assumption that the solutions following a fissure are constantly changing. In the case of banded veins like those of Clausthal where one finds repeated alternations of one non-metallic mineral with sulphides, changing solutions, as an explanation is hard to conceive.

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[19] *Econ. Geol.*, vol. **27**, p. 419, 1932.

Colloform Banding

The term colloform has been widely used by geologists,[21] to include a number of structures that have been usually attributed to colloidal deposition. Colloform structures when examined in thin section appear to be crystalline, or sub-crystalline (amorphous).

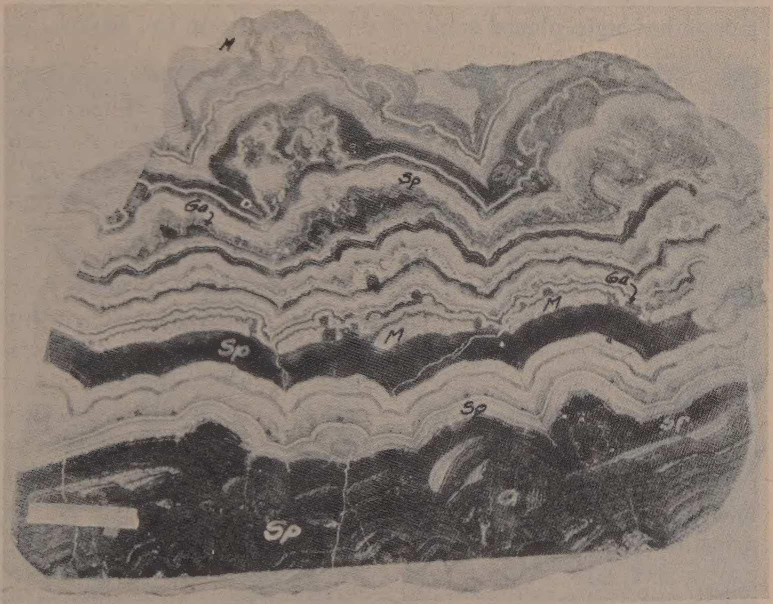

Fig. 3. Colloform bands of zinc sulphide, the bands colored probably by adsorbed iron compounds. Moresnet, Belgium.

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[20] The Ore Magmas, vol. **II**, p. 677, 1923.

[21] Rogers, A. F., *Jour. Geol.*, vol. **25**, p. 518, 1917.

The former is exhibited chiefly by carbonates, while the latter appears to be represented mainly by silicates and sulphides.

Since many of the bands observed in fissure veins, and which are ordinarily termed colloidal, consist of well crystallized minerals, one may question whether they represent colloidally deposited minerals which have subsequently crystallized, or whether they have actually originated by crystallization from molecular solution. Many of the carbonates show a colloform banding which is in reality caused by the feathery nature of the crystals.

The colloidally deposited zinc sulphide from Moresnet, Belgium (Fig. 3), shows a strikingly banded appearance, with alternating light and dark ribbons. This rhythmic coloration, in bands of uniform texture is probably caused by the adsorption of varying amounts of iron compounds. Discontinuous bands of galena and marcasite may be interbanded with the zinc sulphide. The lead sulphide was undoubtedly deposited from a molecular solution, which diffused through the colloidal zinc sulphide, the cubes of galena having replaced some of the sphalerite in the bands.

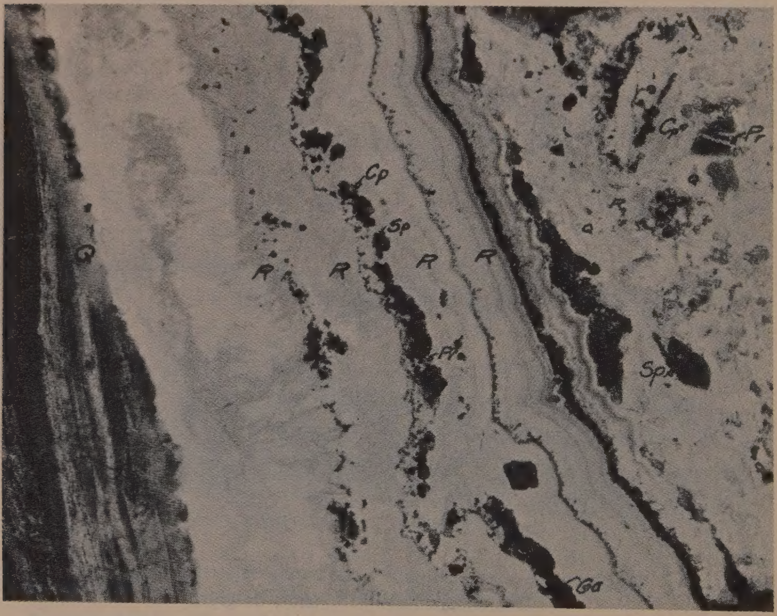

Fig. 4. Colloform bands of rhodonite (R) with sulphides, chalcopyrite (cp), sphalerite (sp) and pyrite (pr). Area beyond last continuous band shows portions of collapsed ones. Initial crust of quartz (q) on wall rock. Kapnik, Roumania.

Another interesting specimen, representing a portion of a banded vein from Kapnik, Roumania, is shown in Fig. 4. This shows alternating bands of colloidal and crystalline rhodonite, as well as galena, sphalerite, chalcopyrite and pyrite. The sulphides which have euhedral outlines, occur sparingly, and are probably contemporaneous. The rhodonite shows that the character of the material deposited changed from a colloidal to crystalline texture as precipitation progressed.

In seeking an explanation for colloform structure, it is suggested that the colloidal particles may have been thrown down from a supersaturated solution by rapid crystallization or condensation, and precipitated on the walls by a process of adsorption, or possibly in some cases by a difference of electrical potential[22] between the solution and the wall rock.

Coloration Banding

Minerals susceptible to the coloring effects of slight amounts of foreign material adsorbed or in solid solution; or more rarely minute inclusions, such as are noted in quartz, fluorite or tourmaline, may exhibit a well defined banded structure due to variations in the amount and character of the coloring agent.

Bands of Impurities

Should the deposition of foreign matter which may have been included in the bands, become too great, it may separate the solid from the solution phase of the mineral, and cause the development of a second crust of the latter, when the active deposition of foreign matter ceases.

Replacement Banding

Many irregularly banded veins, are undoubtedly the result of replacement along fractures[23] or shear planes in the vein material. These permit ready access of solutions, which replace the minerals along the fractures. Bands of clay and other colloidal minerals, or the boundary line between crusts may allow mineral solutions to diffuse through them and replace the bordering bands.

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[22] Pictou, H., and Linder, S. E., The Electrical Connection of Certain Dissolved Substances; *Jour. Chem. Soc. Trans.*, vol. **71**, Pt. I, p. 568, 1897.

[23] For interesting cases of this see: Bornhardt, W., Gangverhältnisse des Siegerlands und seiner Umgebung; *Archiv. f. Lagerstattenforschung*, Heft. **8**, Pt. II, 1912.

Reopening and Filling

Fractures caused by the reopening of a vein which shows no original banding, may become filled with different minerals, thereby producing a banded appearance.

Summary

It is probable that the banding in some fissure veins is caused by filling of shear fractures in an originally unbanded vein, by replacement along the contact of two crusts, by the change in color of different crusts of the same mineral, or the operation of diffusion in gels as outlined by Liesegang. It is suggested, however, that in those veins which show a more or less regular crustification, particularly due to alternating bands of two different minerals, that the process of rhythmic fractional crystallization, as previously described, explains as well as any the mode of deposition of the individual bands. The process is in conformity with the laws of physical chemistry, and seems more logical than the assumption that the solutions rising in the fissure were constantly changing.

Attention is also called to the fact that in some veins there is a series of bands of the same mineral which show a change from colloidal or finely crystalline texture in the earliest deposited crust, to coarsely crystalline texture in the last. This change is thought to be due to a decrease in the degree of supersaturation of the solution, or decrease in rate of crystal growth due to cooling.

The writer wishes to acknowledge his indebtedness for suggestions and criticisms to Professors Ries, Gill and Nevin of Cornell University, and Professor E. S. Moore of Toronto University.

TWO DIMENSIONAL DENDRITES AND THEIR ORIGIN

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INTRODUCTION

Many writers have mentioned the occurrence of dendritic growths and a number of descriptions of various shapes and occurrences have been noted in mineralogy and geology textbooks. However, the literature has little regarding the origin of this interesting structure from a mineralogic standpoint.

The only statements of origin found by the writer are articles by Schoedler[1] and Lewis.[2] Lewis presented what is perhaps the most extensive discussion of the subject. He described some earthy hydrous manganese oxide dendrites found in a white Triassic sandstone. He gave a brief discussion of their origin, with some suggestions as to the origin of dendrites in other types of rocks. He did not give their mineral composition but it was probably psilomelane or wad.

During the course of this study it was found that all dendrites fell into a natural grouping on the basis of shape. First, those that were dominantly two dimensional, i.e., had considerable length and breadth but were of negligible thickness, and second, those that were three dimensional such as shrub-like deposits in moss agates. The origin of these two groups is different and each constitutes a separate field of study. Further study of the three dimensional forms is in progress.

In order to facilitate description, two dimensional dendrites are placed in two groups. The first group, designated as simple dendrites, includes blade-like deposits with no branches[3] and also blade-like forms that may have one or more broad branches but are not intricately subdivided. The second group is designated as complex and includes those forms that are intricately branched. These are the type usually thought of when dendrites are mentioned (Fig. 1).

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[1] Schoedler, Friedrich, Elements of Geology and Mineralogy, p. 56, Joseph Griffin and Co., *London*, **1851**.

[2] Lewis, H. C., On Dendrites: *Proc. Acad. Nat. Sc., Phila.*, p. 278, **1880**.

[3] As in plant description, the main body is called the trunk or stem, and the parts that diverge from it the branches.

DEFINITION OF DENDRITES

A dendrite is a naturally occurring inorganic deposit, resembling a floral growth in outline, that is found on or in a rock or mineral.

Dendrites may show a great many differences in external form. They may be simple, flat, lath-like forms resembling blades of grass, or have a few broad branches smooth in outline, or, again, they may be as complex in outline as a fern or fully leaved tree.

COMPOSITION

Most dendrites are reported as being composed of manganese oxide although the iron oxides, hematite and limonite, have been found fully as common and even more abundant by the writer. In fact, conditions surrounding solubility and deposition being equal, the ratio of abundance of iron oxide dendrites to manganese oxide dendrites should approximate the ratio of iron to manganese in the earth's crust, namely about 55:1. It may be that many iron oxide dendrites have been overlooked, and thus only manganese oxide dendrites cited in the literature. Although manganese oxide is perhaps more common in surface waters than we think, the extreme commonness and widespread distribution of iron compounds from which limonite and hematite may be derived would account for the abundance of dendrites of this composition.

Because of the extreme commonness of iron and manganese oxide dendrites the question arose as to the possibility of compounds other than oxides being able to produce these forms, none having been cited in the literature as being common. The writer carried on a number of experiments to grow dendrites by using a variety of salts. True dendritic structures were produced from sulfates, nitrates, and chlorides.

OCCURRENCE AND DISTRIBUTION

Dendrites occur not only in igneous, sedimentary, and metamorphic rocks but also in various minerals. The collection at the University of Missouri includes specimens in sandstone, limestone, shale, chert, opal, flint, dolomite, barite, basalt, diorite, rhyolite, trachyte, orthoclase, andesite, agate, chalcedony, slate, marble, and clay. In fact, dendrites probably occur in all the common rocks and minerals. They are less common in shales and clays than in any other rock. This is probably due to the fact that shales and clays are relatively impervious to the passage of percolating waters, and also to the fact that fractures in these rocks are sealed soon after their formation. Furthermore, the colors of many dendrites are so nearly like the enclosing rocks that they are not noticed. Only when there is a contrast of colors or an unusual shape, is attention attracted to the dendrites.

Dendrites are found most commonly along joint planes, fractures, and bedding planes. Bedding planes should be ideal zones for the growth of dendrites and doubtless contain them in abundance. However, in outcrops the bedding surface is so seldom exposed that the relative number of dendrites cannot be ascertained. Consequently, most specimens are found in highly jointed or fractured rocks where there is a source of material and sufficient ground water for transportation.

Simple and complex forms may be found in the same locality and in the same rock. The simple forms are usually associated with the larger openings. As the openings decrease in size the complexity of the structures usually increases. Many openings have either increased or decreased in size since the deposition of the dendrites either by solution along the joint plane or by the opening or closing of the joints by earth movements. Therefore, it is difficult to state the size of opening necessary for the deposition of any particular form. The width of the fissure is doubtless small and probably approximates a capillary opening in size.

Capillary openings (sheet openings) are between 0.254 and 0.0001 mm. wide. In openings of this type the dendrites may grow upward due to capillary action, or they may spread laterally. In many cases, however, the openings are super-capillary in size and the dendrites grow downward because the waters bearing the mineral salts migrate downward due to gravity. Where the openings in the rocks are super-capillary simple dendrites predominate because the solutions seep downward along irregularities of the wall rock and deposits are made along the channels. Little or no branching is found. In many instances the wide part of the fissure is completely filled with material of which the dendrites are composed. The growth of the dendrites sealed the fissure against the further percolation of ground waters and permitted the accumulation of mineral matter in the wide part of the opening.

Megascopic Description

Dendrites that grow in joints or fracture planes are forced to become two dimensional, that is, their length and breadth are far in excess of their thickness which is limited to the width of the opening in which the dendrites are formed. Their length and breadth may be nearly the same, or one dimension may greatly exceed the other. Some may be a foot or more in length and others microscopic in size.

In cross section the dendrites are usually broadly ovate with minor indentations around the edge. The outside of the stems of some may be smooth at one point and rough or strongly indented at other points. One side of the dendrite may be smooth and the other irregular. This is to be expected when a dendrite is deposited on a porous or irregular surface. The rough irregular side represents the deposit in the interstices between the grains of the rock on which the dendrite was deposited. If the dendrite did not fill the fissure then the side of the dendrite away from the rock is smooth. If the fissure is filled with dendritic material then both sides of the dendrite are rough, the irregularities on the surface of the dendrite articulating with the irregularities on the surface of the rock fissure. Dendrites also grow in smooth joints, and the surfaces are smooth in the same proportion.

Dendrites usually begin as a simple blade that becomes more complex as it develops from the initial point of growth or as the planes in which the dendrites are growing come closer together. Some joint planes are completely coated with dendritic material where the opening is wide, but complex forms are produced where the joint plane pinches together (Fig. 2).

The branches are not regularly spaced. They may be both opposite and alternate along the same stem, or many branches may diverge from one point, either near the base or some distance away from it. A number of branches may go out from one side of the stem without corresponding branches on the other side. The broadest branches are usually near the base of the stem. Exceptions to this are found where the solutions have been guided along some particular channel and a concentration of the deposit has thus been brought about.

The ends of the branches of the dendrites are dominantly of two types. The first, and most abundant, is rounded, subcircular, or ovate. In some instances the end is wider than the stem of which it is a part. The second type is acicular and usually there is the tapering of the branch to a sharp point.

Dendrites may have a variety of colors, but red, yellow, brown, black, and green predominate. In fact, other colors are rare. The cause of the abundance of these tints is evident. Since most dendrites are formed of iron and manganese oxides, the color of the oxides will predominate. A number of green dendrites were observed in shales which probably represent mixtures of ferrous and ferric iron.

MICROSCOPIC DESCRIPTION

The materials of which nearly all dendrites are composed are amorphous, at least no crystalline substance has as yet been observed. The dendrites are likewise opaque.

There is little difference between the megascopic and microscopic appearance. The microscope reveals a more detailed splitting and bifurcation of the branches as well as more details of the irregularities of the edges. Some dendrites were found to be made up of a series of flat but rounded aggregates, similar to oolites. No nuclei were observed, and the aggregates tended to be botryoidal and overlapping although some segregated flattened spheres were seen. These rounded aggregates may merge into three dimensional dendrites.

ORIGIN OF DENDRITES

The possibility of making dendrites artificially was suggested by Schoedler[4] in 1851. He states:

> We find frequently tracings resembling trees or mosses between slabs or plates of rock, forming *Dendrites*, which may easily be imitated, and their origin illustrated by placing some finely levigated clay between two plates of smooth glass, or stone, and pressing them slightly together. A variety of ramified designs are thus obtained, similar to the hardened formations occurring in Nature, which may easily be mistaken for petrified moss or other vegetable objects.

An attempt was made to reproduce two dimensional dendrites by several experimental methods. In some cases very good dendrites were formed, in others only partial success was obtained, and in some experiments the results were negative. The best artificial dendrites were grown in the laboratory along joint planes and by the distribution of suspended material due to surface tension of evaporating waters. In each case dendrites similar to those found in nature were produced. It is of interest to note that finely divided suspended materials, on the evaporation of the water, left dendritic structures in every way similar to those formed chemically.

[4] *Op. cit.*, p. 56.

Growth of Dendrites in Joint Planes

In growing dendrites in joint planes, several strips of ordinary window glass about two and one-half inches square were bound together. The spaces between the plates of glass simulated the joint planes in rocks. The plates of glass were then placed beneath a funnel which contained a number of crystals of iron sulfate. Water was allowed to drip over the iron sulfate, to pass down the funnel stem and onto the upturned edges of the plate of glass. This process was allowed to continue for about a week. The plates, with the edges up, were then set aside for several days to permit any of the ferrous iron in the joints to become oxidized.

The resulting dendrites grew downward from the place where the transporting liquid fell on the upturned edges of the glass plates. The base of the dendrites tended to radiate fan-like from the source of the iron bearing solutions. The dendrites were complex and consisted of slender frond-like forms averaging two centimeters in length and three millimeters in width. The stems had many branches (about 30) the ends of which were sharply pointed.

The formation of the dendrites probably started as soon as the water began to penetrate the openings between the plates. As the dendrites formed, the openings were progressively sealed against the further entrance of solutions and growth ceased. The form of the dendrites was probably influenced by the surface tension of the transporting liquid. The crystal structure of some iron compound may have played a part, but the form of the dendrite could not be directly related to it.

The iron in the above experiment was probably transported as the hydroxide and was oxidized to limonite by oxygen from the air, or by the oxygen in solution in the water. Oxidation started as soon as the water came in contact with the crystals, and consequently some of the limonite was transported in suspension before coming in contact with the glass plates, but the amount was undoubtedly small. Most of the oxidation occurred between the plates.

Good dendrites were produced by using a water solution of cobalt nitrate. Several glass plates separated by onion skin paper were placed in the solution. For several days no dendrites were produced but as the concentration of the cobalt nitrate increased, due to the evaporation of water, small dendrites started to form between the plates and along the contact of the solution and the beaker. In a short time (about two hours) the dendrites grew to be a centimeter in length. The fact that dendrites grew on the surface of the beaker suggests that two walls closely spaced are not necessary to their formation. No natural occurrence has been noted, however, where two walls are not present.

Dendrites Resulting From Surface Tension of Evaporating Liquids

A number of experiments were carried on to study the rearrangement of suspended materials in a liquid as the liquid evaporated. The materials suspended were limonite, pyrolusite, and kaolin.

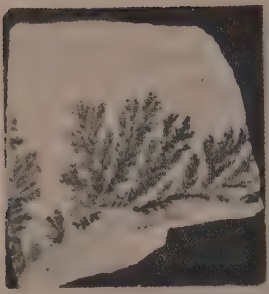
In each case the mineral was ground as fine as possible in an agate mortar. About 0.05–0.10 gram portions were placed on microscope slides. A drop of water was placed on the powdered mineral and stirred with a needle in order to suspend as much of the powder as possible. A cover glass was placed on the slide which was then allowed to stand until the water had completely evaporated. Designs distinctly dendritic in shape resulted in most cases (Fig. 3).

Aggregates, rounded in outline, were numerous, suggesting that the surface tension of the water caused minute flattened drops to form. When the water evaporated a rounded deposit resulted since the suspended material would tend to be concentrated about the outside of the drop.

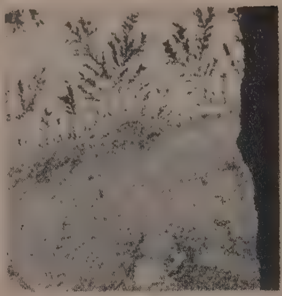
Associated with these deposits were numerous curved branch-like deposits, indicating that the evaporating liquid tended to assume a spherical shape but was prevented by the cover glass.

Another design that formed commonly when a large amount of powdered mineral was used is shown in Fig. 4. When kaolin was used the resulting dendrites were flat narrow bands about one millimeter in width (Fig. 3). When the mineral used was limonite the dendrites formed were about two to three millimeters wide (Fig. 4). The branches were irregular in outline and diverged at a large angle from the main stem, forming a netlike pattern. Around the edges of the stems faint curved dendritic branches pointed inward. Dendrites similar to this type have been found in the flint clays near Rolla, Missouri (Fig. 5).

As stated before, the most common types of dendrites are those formed in fissures, cracks, joint planes, and bedding planes. The mechanism whereby dendrites are formed in these places is per-



1.



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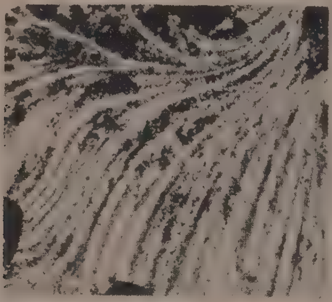

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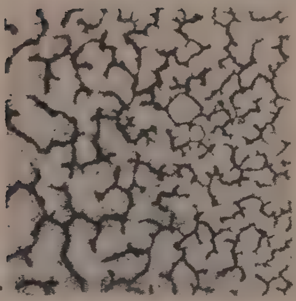
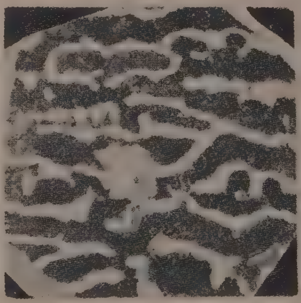




5.

Explanation of Figures

FIG. 1. Complex dendrites of limonite on Mississippian (Burlington) chert. ×1.5.

FIG. 2. Dendrites developed in a wedge-shaped joint plane. At the wide part of the joint the entire surface is covered with limonite. The complex structure developed where the joints pinched together. ×1.7.

FIG. 3. Artificial dendrites formed by the action of surface tension on drying liquids. The material used was pyrolusite. ×4.

FIG. 4. Net-like dendrite pattern of artificial dendrites formed by surface tension. They are kaolin. ×2.

FIG. 5. Limonite dendrites in flint clay. ×1.5.

haps identical in all cases. The transporting agent is almost invariably ground water, and salts forming the dendrites may be transported considerable distances, but the majority of dendritic materials are carried only short distances. Long transportation suggests solubility, but dendrites are usually composed of insoluble oxides.

In some cases the dendritic materials are doubtless derived from the weathering of the wall rock in which they are deposited. In basic rocks the decomposition of the ferromagnesian minerals along the joint planes provides a ready source for the dendritic materials. In dolomites the ferrous iron commonly isomorphous with the magnesium supplies dendritic material. In limestones and shales the breaking down of pyrite liberates an abundance of iron to supply the ground waters.

Time of Origin

It can be readily seen from the foregoing discussion that two dimensional dendrites are dominantly epigenetic in origin. They were formed in cracks and fissures after the enclosing rocks were consolidated.

Summary

The widespread occurrence of dendrites has permitted a study of their composition, shape, and origin. Duplication of both simple and complex dendrites in the laboratory, under conditions similar to those in nature, has suggested a number of ways in which these forms may be produced. The most common are by deposition in joint planes, and by the influence of surface tension upon evaporating liquids.

LOGICAL SYMBOLS FOR POINT SYMMETRY GROUPS

WALTER SOLLER, *Dept. of Physics, University of Arizona.*

The present symbols for designating the thirty-two point symmetry groups in crystallography are needlessly complicated. These symmetry groups are so simple and logical that the fundamental symmetry elements and their relative positions can be designated completely by a newly devised set of symbols. Rather than having symbols that the student must learn and associate with the groups, the symbols can be an aid to learning the groups. The symbols which the author is proposing have so many advantages over the Schoenflies symbols that they warrant being brought to the attention of mineralogists.

With the Schoenflies symbols in order to know what groups the various symbols represent, it is necessary to learn the meaning of the principal letters, C, V, D, S, T, and O, and the subscripts or indices, i, h, v, d, s, 1, 2, 3, 4, and 6. Even after the meaning is known these letters and figures only in the simpler cases indicate the least group of symmetry operations which fully identify the class of symmetry. A logical set of symbols can be devised by recognizing that the fundamental symmetry elements are: rotation axes, rotary reflection axes, a horizontal symmetry plane, and a vertical symmetry plane, whereby the above eleven letters can be reduced to only two, the subscripts h and v.

The recognition of the rotary reflection axes in general as fundamental elements helps to bring about a considerable part of the simplification. A two-fold rotary reflection axis is equivalent to a center of symmetry; also a six-fold rotary reflection axis is equivalent to a three-fold axis, and a center of symmetry, but a four-fold rotary reflection axis in the tetragonal and cubic systems has no equivalent group of symmetry elements. Therefore, it is better to recognize all rotary reflection axes as fundamental symmetry elements.

In this new set of symbols the principal axis of the crystal is designated by a large figure such as 1, 2, 3, 4, or 6 according to the degree of symmetry of the principal axis, and in those cases where the principal axis is a rotary reflection axis, the symbols are designated by $\bar{2}$, $\bar{4}$, or $\bar{6}$. The minus sign above the figure is used to indicate that the rotary reflection axis is of a lower symmetry than that of a corresponding simple, rotation axis. Further, the subscript

2, as for example, 3_2, signifies that in addition to a three-fold principal axis the group contains a two-fold axis at right angles to the principal axis, and a subscript *h*, for example, 3_h, signifies that the group contains a horizontal plane of symmetry (that is, a plane perpendicular to the principal axis), while a subscript *v*, for example, 3_v, signifies that the group contains a vertical plane of symmetry (that is, a plane through the principal axis). If in addition to a two-fold axis at right angles to the principal axis the group contains a horizontal reflection plane, the subscript *h* is added, as for example, 3_{2h}.

These symbols have only one meaning whenever they are used; for example, 6_{2h} signifies a six-fold principal axis with both a two-fold axis and a symmetry plane at right angles to the principal axis, while $\bar{6}_2$ means a six-fold rotary reflection principal axis with a two-fold axis at right angles to it. The above described symbols indicate how the symbols for all groups can be formed, except those of the cubic system.

Those groups belonging to the cubic system have in addition to a principal axis and a two-fold axis at right angles to the principal axis, also a three-fold axis. This three-fold axis is the principal diagonal of a cube in which the principal axis passes perpendicularly through the center of the base of the cube and the two-fold axis perpendicularly through the center of the front face of the cube. For example, the lowest symmetry group in the cubic system is 2_{23}, which signifies a two-fold principal axis with a two-fold axis at right angles to it and a three-fold diagonal axis in the position with respect to these two two-fold axes as described above.

The next higher symmetry group is 2_{23h}. This designates the same set of axes as described for 2_{23}, but in addition, this group possesses a horizontal reflecting plane. Here again the subscript 3 can mean only a three-fold diagonal axis in the position described above.

Since the principal axis, the perpendicular two-fold axis, the diagonal three-fold axis, and the reflecting planes have always only the relative positions described above, the symbols for any group, therefore, not only designate the fundamental symmetry elements of the group (the least group of symmetry elements which fully identify the class of symmetry), but also their relative positions.

All the other symbols for the thirty-two point groups arranged according to crystal systems together with the corresponding

TABLE 1

Group Name		Schoenflies Symbol	New Symbol	Equivalent Points
Groth	Schoenflies			
Triclinic System				
Asymmetric pedial	Hemihedry	C_1	1	1
Pinacoidal	Holohedry	$C_i=S_2$	$\bar{2}$	2
Monoclinic System				
Domatic	Hemihedry	C_s	1_h	2
Monoclinic sphenoidal	Hemimorphic hemihedry	C_2	2	2
Monoclinic prismatic	Holohedry	C_{2h}	2_h	4
Orthorhombic System				
Rhombic pyramidal	Hemimorphic hemihedry	C_{2v}	2_v	4
Rhombic bisphenoidal	Enantiomorphic hemihedry	$V=D_2$	2_2	4
Rhombic bipyramidal	Holohedry	$V_h=D_{2h}$	2_{2h}	8
Rhombohedral System				
Trigonal pyramidal	Tetartohedry	C_3	3	3
Ditrigonal pyramidal	Hemimorphic hemihedry	C_{3v}	3_v	6
Trigonal trapezohedral	Enantiomorphic hemihedry	D_3	3_2	6
Rhombohedral	Hexagonal tetartohedry of the second sort	$C_{3i}=S_6$	$\bar{6}$	6
Ditrigonal scalenohedral	Holohedry	D_{3d}	$\bar{6}_2$	12
Tetragonal System				
Tetragonal bisphenoidal	Tetartohedry of the second sort	S_4	$\bar{4}$	4
Tetragonal scalenohedral	Hemihedry of the second sort	$V_d=D_{2d}$	$\bar{4}_2$	8
Tetragonal pyramidal	Tetartohedry	C_4	4	4
Tetragonal bipyramidal	Paramorphic hemihedry	C_{4h}	4_h	8
Ditetragonal pyramidal	Hemimorphic hemihedry	C_{4v}	4_v	8
Tetragonal trapezohedral	Enantiomorphic hemihedry	D_4	4_2	8
Ditetragonal bipyramidal	Holohedry	D_{4h}	4_{2h}	16

Hexagonal System

Trigonal bipyramidal	Trigonal paramorphic hemihedry	C_{3h}	3_h	6
Ditrigonal bipyramidal	Trigonal holohedry	D_{3h}	3_{2h}	12
Hexagonal pyramidal	Tetartohedry	C_6	6	6
Hexagonal bipyramidal	Paramorphic hemihedry	C_{6h}	6_h	12
Dihexagonal pyramidal	Hemimorphic hemihedry	C_{6v}	6_v	12
Hexagonal trapezohedral	Enantiomorphic hemihedry	D_6	6_2	12
Dihexagonal bipyramidal	Holohedry	D_{6h}	6_{2h}	24

Cubic System

Tetrahedral pentagonal dodecahedral	Tetartohedry	T	2_{23}	12
Diacisdodecahedral	Paramorphic hemihedry	T_h	2_{23h}	24
Hexacistetrahedral	Hemimorphic hemihedry	T_d	$\bar{4}_{23}$	24
Pentagonalicositetrahedral	Enantiomorphic hemihedry	O	4_{23}	24
Hexacisoctahedral	Holohedry	O_h	4_{23h}	48

Schoenflies symbols are given in Table 1. These symbols indicate the fundamental elements of symmetry of each group. All other elements of symmetry and their relative positions can be determined from the fundamental symmetry elements as will be illustrated by constructing a stereographic projection of the equivalent points of several groups, such as groups 4_{2h}, 6_v, and $\bar{4}_{23}$. We will in each case assume the elements of symmetry and their relative positions given by the symbol and will start with one general point in the positive octant, deriving all the equivalent points by applying only the symmetry operations indicated by the symbol for that group. We will mark this first point 1 and the following points 2, 3, etc. in the order in which they are formed by the symmetry operations. The figure on the left hand side of a point is the order number of that point designated by the circle, while the right hand figure is the order number of that point designated by the cross. After all of the equivalent points of the group are found, the remaining symmetry elements can be seen at a glance from the position of the equivalent points. Figure 1 is a stereographic projection of the equivalent points of group 4_{2h}. The elements marked *a*, *b*, and *c* are the fundamental elements indicated by the symbol. Operation "*a*" gives points 2, 3, and 4. Operation "*b*" gives points 5, 6, 7, and 8. Opera-

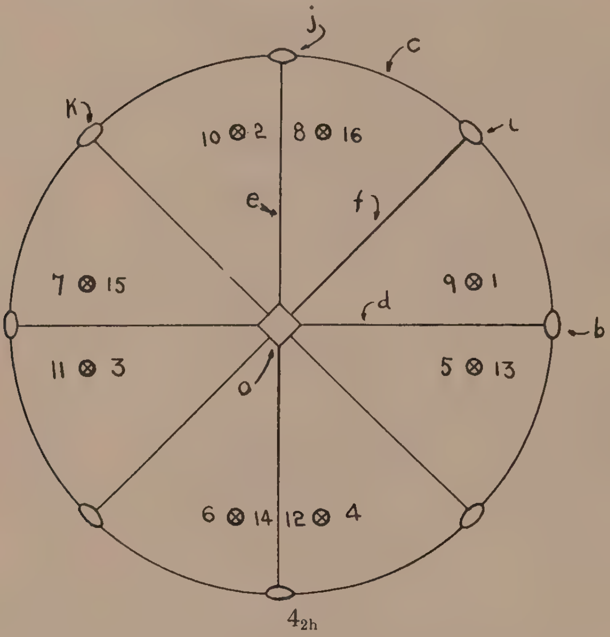

j
c
K
l
10 ⊗ 2
8 ⊗ 16
e
f
7 ⊗ 15
9 ⊗ 1
d
b
11 ⊗ 3
5 ⊗ 13
o
6 ⊗ 14
12 ⊗ 4
4_{2h}

FIG. 1

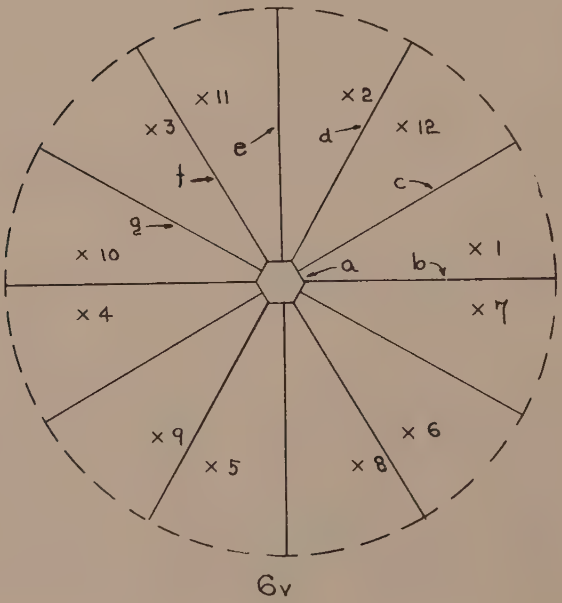
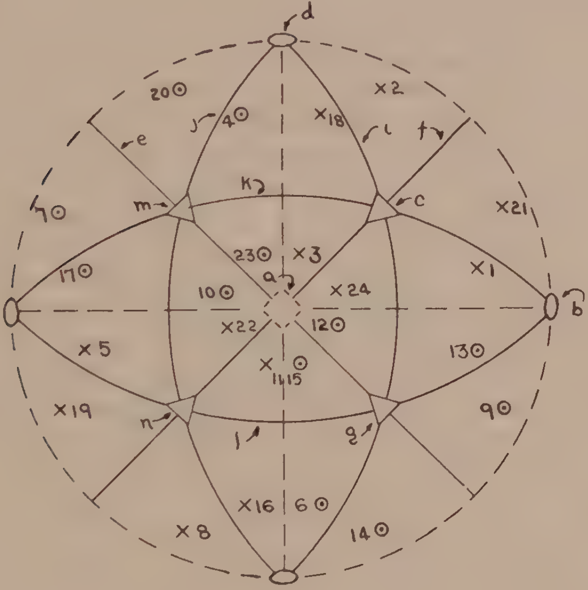

× 11
× 2
× 3
e
d
× 12
f
c
g
× 10
a
b
× 1
× 4
× 7
× 9
× 5
× 8
× 6
6v

FIG. 2

tion "*c*" gives points 9, 10, 11, 12, 13, 14, 15, and 16. From the position of the equivalent points it can be seen that the group also contains four vertical planes, *d*, *e*, *f*, *g*, and three more two-fold rotation axes, *i*, *j*, *k*, and a center of symmetry.

Figure 2 is group 6_v. The elements marked *a* and *b* are the fundamental elements indicated by the symbol. Operation "*a*" gives points 2, 3, 4, 5, and 6. Operation "*b*" gives points 7, 8, 9, 10, 11, and 12. From the position of the equivalent points it can be seen that the group also contains five more vertical planes, *c*, *d*, *e*, *f*, and *g*.



$\bar{4}_{23}$
FIG. 3

Figure 3 is group $\bar{4}_{23}$. The elements marked *a*, *b*, and *c* are indicated by the symbol. The element "*a*" is drawn in a broken line to indicate that the principal axis is a four-fold rotary reflection axis, $\bar{4}$, to distinguish it from a simple rotation axis which is indicated by the same symbol in a solid line (see Fig. 1).

In the cubic system it is easier to construct the stereographic projection of the equivalent points by first performing the three-fold rotation operation before the principal axis rotation and the other operations. Operation "*c*" gives points 2 and 3. Operation "*a*" gives points 4, 5, 6, 7, 8, 9, 10, 11, and 12, and operation "*b*" gives points 13, 14, 15, 16, 17, 18, 19, 20, 21, 22, 23, and 24. From these points it is apparent that the group also possesses another two-fold axis, *d*, and two vertical planes, *e*, and *f*, four diagonal planes, *i*, *j*, *k*, and *l*, and three more three-fold axes, *m*, *n*, and *g*.

A special feature of this new system of symbols is that the number of equivalent points in the group is indicated by the symbol itself. As a letter indicates a two-fold operation, it has an equivalent numerical value of 2. The number of equivalent points then is the product of all the figures and letters needed to constitute the symbol. In the three examples given above, the number of equivalent points is determined from the symbols as follows: From the symbol 4_{2h} we obtain (4) (2) (2) = 16 equivalent points. From the symbol 6_v we obtain (6) (2) = 12 equivalent points, while from the symbol $\bar{4}_{23}$ we obtain (4) (2) (3) = 24 equivalent points. All of these equivalent points agree with the number of equivalent points shown on Figures 1, 2, and 3. In the same way the number of equivalent points given in the last column of Table 1 can be seen to be indicated by the corresponding symbol.

These symbols can be used to designate the space groups as subdivisions of the point groups by superscripts, 1, 2, 3, etc. in exactly the same way that the space groups are designated by the Schoenflies symbols, as only subscripts are used to indicate point groups.

TABLE II

			1	1_h					
		$\bar{2}$	2	2_h	2_v	2_2	2_{2h}	2_{23}	2_{23h}
			3	3_h	3_v	3_2	3_{2h}		
$\bar{4}_{23}$	$\bar{4}_2$	$\bar{4}$	4	4_h	4_v	4_2	4_{2h}	4_{23}	4_{23h}
	$\bar{6}_2$	$\bar{6}$	6	6_h	6_v	6_2	6_{2h}		

In Table 2 the groups are rearranged to show their interrelationship. The five groups with a two-fold principal axis have corresponding groups with three-, four-, and six-fold principal axes, which form the rectangular block of twenty groups shown in the table. The other groups fit logically around this block. Since a one- or three-fold rotary reflection axis would not bring a point back to its original position after a rotation of 360° it is obvious that only two-, four-, and six-fold rotary reflection axes are possible. Combinations of a rotary reflection axis with a horizontal reflection plane do not occur, since this condition would raise the symmetry of the axis to a simple rotation axis.

In this arrangement of the groups it can be noted how with only rotation and rotary reflection axes and horizontal and vertical reflection planes all the groups build up logically from the lowest symmetry to the highest possible crystal symmetry group. This arrangement also brings out the fact that the special development to diagonal three-fold axes is possible for only those groups having a two-fold axis perpendicular to a principal axis of lower symmetry than six-fold rotary reflection. The thirty-two point groups can be remembered easily by recalling the arrangement shown in Table 2.

From Table 1 it will be noticed that all these new symbols not only designate the groups, but actually indicate the symmetry of the groups, as all the necessary symmetry elements and just those sufficient to completely classify the group are given in each symbol. These are arranged in the order of their relative importance by making the principal axis the main figure of the symbol. These symbols, therefore, actually represent the groups rather than just designate them as the Schoenflies symbols do.

Besides being more adequate the new symbols are far simpler, as only axes and planes need be designated. A figure as used in these symbols designates an axis completely, that is, the kind of axis and its relative position. This leaves only two letters necessary in these symbols to designate the planes. With only these two things to remember and with the symbol actually representing the symmetry of the group the symmetry of the group is seen at a glance from the symbol. For example in Table 1 these symbols indicate the relationship between the thirty-two symmetry groups and the seven crystal systems classification. First, all orthorhombic principal axes are two-fold, and all tetragonal principal axes are four-fold. Then, the rhombohedral system contains all the groups with three-fold principal axes, except those having horizontal reflection planes and all the groups having $\bar{6}$ principal axes, while the hexagonal system contains only those groups having three-fold axes with horizontal reflection planes, and all the groups with simple six-fold rotation axes. The distinguishing feature of the cubic system groups, the three-fold diagonal axis, is also indicated by these symbols.

The above relations are due, of course, to the fact that the holohedry group of each crystal system is the symmetry of the space lattice of that system. The crystal system classification, then, is really a symmetry group classification of the space lattices of crystals. All other lower groups in any one crystal system are produced by the interpenetration of these similar lattices which accounts, for example, for the impossibility of horizontal reflection planes in the rhombohedral system, since the rhombic space lattice has a rotary reflection principal axis, and as previously explained precludes horizontal reflection planes. All of these relations and many more are recognized directly from the symbols.

In addition to all of the advantages cited which these new symbols have over the Schoenflies symbols, over half of them are designated by fewer figures and letters than the corresponding Schoenflies symbols.

The writer has found these symbols a great help to mineralogy students in their course of "X-Ray Analysis of Crystalline Materials." Particularly were these symbols helpful in determining the space groups from the X-ray data.

URANINITE FROM LAC PIED DES MONTS, SAGUENAY DISTRICT, QUEBEC

H. V. ELLSWORTH[1] AND F. FITZ OSBORNE.

In 1893 or 1894 J. Obalski, then inspector of mines for Quebec collected a crystal of uraninite from a pegmatite dike worked for muscovite on the north side of Lac Pied des Monts, de Sales township, Charlevoix county, about 18 miles northeast of Murray Bay. This is the easternmost occurrence of uraninite in Canada. Obalski described the crystal about ten years later in the *Journal of the Canadian Mining Institute*, vol. VII, pp. 245–256, 1904. In 1915 the crystal was bought by the Department of Physics of McGill University. Dean A. S. Eve, Director of the Department of Physics, has kindly allowed the writers to describe the crystal and to saw 4-1/2 grams from it for analysis.

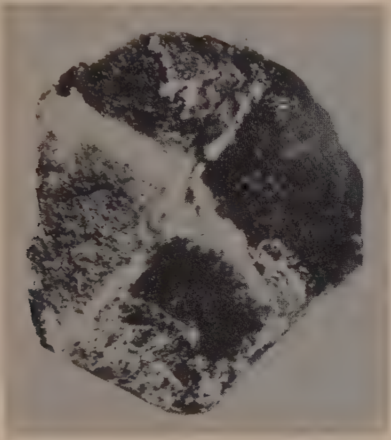


FIG. 1. Uraninite crystal, Pied des Monts, Quebec. (Natural size.)

The crystal, which is about two inches in diameter, is part of a dodecahedron with six faces developed (Fig. 1). The faces show a coating of deep orange to brown gummite, which forms a covering about 1 mm. thick on the parts of the faces near the ends of the cube axes. About two grams of quartz adhered to one end of the crystal; this was removed and a thin coating of gummite and uranophane found beneath it. The fractured surfaces of the crystal are free from visible alteration products.

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[1] Published with the permission of the Director, Geological Survey of Canada, Department of Mines, Ottawa.

The crystal weighed 375 grams when found, and the density of the crystal, including alteration products and quartz, was determined as 8.43 by B. J. Harrington.

MINERAGRAPHIC EXAMINATION

The side of the saw-cut opposite to the part analyzed was polished and examined with the reflecting microscope by Osborne. The surface is almost entirely of uraninite, but shows one very narrow series of anastomosing veinlets of an alteration product. Fig. 2 shows the microscope field that contains the most alteration product.

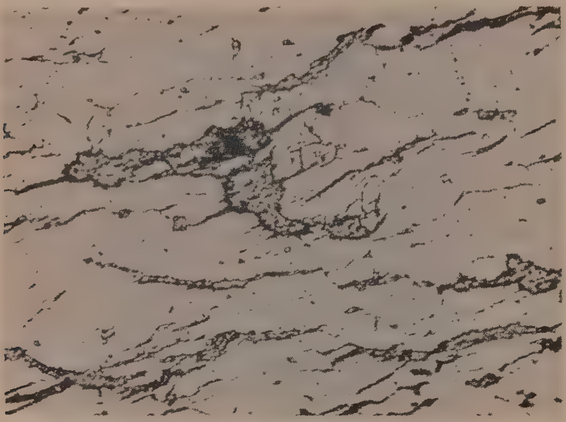

FIG. 2. Veinlets of uranophane cutting uraninite. (×90). Pied des Monts uraninite crystal.

The alteration product was determined as uranophane by etch reactions and comparison with uranophane associated with gummite and uraninite from Mitchell county, N.C. Under the reflecting microscope the uranophane has a blue-green colour against uraninite, gummite is reddish. The internal reflection of uranophane seen with crossed nicols is sulphur yellow, of gummite orange. The etching behaviour of the minerals shown toward the standard etching reagent is given in the table.

	URANOPHANE	GUMMITE
HNO_3	No colour change, surface becomes pitted.	Similar reaction but slower.
HCl	Surface becomes pitted, fumes tarnish pale green, rubs clean.	Surface pitted

KCN	Negative	Negative
$HgCl_2$	Slight pitting	Negative
$FeCl_3$	Slow reaction, fumes tarnish pale brown, slight pitting.	Very slight reaction
KOH	Negative	Negative

The uranophane in the larger areas is feebly anisotropic.

In the course of the tests the behaviour of the uraninite itself was checked. It is negative to all reagents except $FeCl_3$. Murdoch, Davy and Farnham[2] and Short[3] list a slight reaction with this reagent: the surface turns brown and rubs gray. According to Schneiderhöhn and Ramdohr[4] the reaction is negative. This specimen turns brown with the separation of minute acicular crystals in the reagent, and the surface rubs brown.

ANALYSIS

The material used for analysis was a 4-1/2 gram fragment showing no colored alteration products when examined under the binocular microscope. Though black, it lacked the steely colour and almost metallic lustre of the best-preserved uraninites which also have a slightly greater specific gravity and hardness. Nevertheless, judging from past experience, the alteration is not sufficient to cause any serious error in the lead ratio. Owing to the small amount of material available and its apparently good quality no attempt was made to separate a concentrate of maximum density. An analysis on samples of 2 grams yielded the following results:

URANINITE, LAKE PIED DES MONTS, QUE.
Analyst—H. V. Ellsworth

PbO[1]	11.69
$(Pb=10.84)$	
U_3O_8	86.16
$(U=73.08)$	
ThO_2	0.10

[1] Pb = 206
Spec. Grav. = 8.958 at 18.53°C.

$$\frac{Pb}{U+0.36\ Th}=0.148$$

[2] Davy and Farnham, The Microscopic examination of ore minerals, 1920.

[3] Short, M. N., Microscopic determination of ore minerals; *U. S. Geol. Surv. Bull.* **825**, p. 102, 1931.

[4] Schneiderhöhn and Ramdohr, Lehrbuch der Erzmikroskopie, 1931, p. 521.

(Th=0.088)	
(Ce, La, Di)$_2$O$_3$	0.06
(Yt, Er)$_2$O$_3$	0.73
Fe$_2$O$_3$ Al$_2$O$_3$	0.35
MnO	0.14
CaO	0.35
MgO	0.06
SiO$_2$	0.21

This uraninite contains the lowest percentage of thorium and rare earths of any so far examined by Ellsworth. The amount of thorium found is so small that it has no appreciable effect on the lead ratio, as the uranium equivalent is no greater than the probable analytical error of the uranium determination. It is interesting to note that the lead ratio for this low-thorium uraninite is in fairly close agreement with the ratios (0.15 to 0.16), from the best preserved uraninites of the Grenville area of Ontario and Quebec, which contain from 1 per cent to as much as 11 per cent ThO$_2$, whereas uraninite from the Huron claim in south east Manitoba carrying 14 per cent ThO$_2$ yields a lead ratio of 0.26.

In dissolving the uraninite a slight brownish colouration of the solution, apparently due to carbon or hydrocarbon, was noticed. This is interesting in connexion with Obalski's statement (*loc. cit.*) that he also found in the same deposit with the uraninite "a carbonaceous material burning quite easily and leaving ashes containing oxide of uranium" which evidently was a variety of thucholite.

GEOLOGICAL OCCURRENCE

The dike from which the uraninite was obtained is about half way up the high hill on the north side of the lake. It is 15 to 20 feet thick and can be traced for 200 feet along the hillside cutting hornblendic gneiss. The chief constituents of the dike are pink microcline, white albite, and white quartz with much biotite[5] and somewhat less muscovite, all more or less mixed and with no large segregations of either quartz or feldspar. The structure is coarse granitoid to graphic. Mica books are as much as a foot in diameter, and intergrowths of biotite and muscovite occur. Red garnets are plentiful and occasional fragments are almost of gem quality. A few small dark zircon crystals, very fresh and bright, may be seen, and some very small monazite crystals have been found. No traces of uraninite or thucholite can be seen at present.[6]

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[5] Some of the biotite from this mine carries unusually perfect pleochroic haloes which have been very thoroughly studied by D. E. Kerr-Lawson (*University of Toronto Studies, Contributions to Canadian Mineralogy*, **1927**, **1928**).

Lac Pied des Monts is on the northwestern corner of the St. Urbain area mapped by Mawdsley.[7] In that area Mawdsley found only a few dikes of pegmatite and these are younger than the anorthosite. In mapping an area east of this Faessler[8] found a coarse-grained pink granite to have a widespread development. He believes that this is the same age as the Roberval granite named by Dresser[9] from its occurrence near Roberval. Osborne, mapping near Chicoutimi along the Saguenay, found that the dikes older than the anorthosite have taken on an augen structure due to shearing. A few dikes, rather syenitic in composition, appear to be related to the anorthosite and to have escaped shearing, as also did granite pegmatite dikes belonging to the Roberval granite. These observations suggest that the dike containing the uraninite is younger than the anorthosite and probably satellitic to the Roberval, the only granite in this area known to be younger than the anorthosite, for a dike that has yielded 20 tons of commercial muscovite cannot have been sheared to a great extent. Dikes similar to the one mentioned here are abundant in the area east of the Saguenay, where Faessler notes the widespread development of the Roberval granite, suggesting a genetic relationship between the two.

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[6] *Geol. Surv. Can., Econ. Geol. Series*, No. **11,** 1932.

[7] Mawdsley, J. B., *Geol. Surv. Can., Mem.* **152,** 1927.

[8] Faessler, Carl, Geological Explorations of the North Shore Tadoussac to Escoumains; *Quebec Bur. of Mines, Ann. Rept.* **1929,** p. 81, 1930.

[9] Dresser, J. A., Part of the district of Lake St. John, Quebec, *Geol. Surv. Can., Mem.* **92,** p. 26, 1916.

NICKELIFEROUS AND URANIFEROUS ANTHRAXOLITE FROM PORT ARTHUR, ONTARIO

H. V. Ellsworth.[1]

Several years ago specimens of anthraxolite collected near Port Arthur by T. L. Tanton of the Canadian Geological Survey were found by the writer to be slightly radioactive. As Dr. Tanton considers this anthraxolite to be definitely of post-Animikie (late pre-Cambrian) age, and as he states further that by blasting it would be easily possible to obtain the mineral in quantities of 100 pounds or more, it appeared to be worth while to ascertain whether the radioactive element content is sufficient to justify an attempt to determine the age of the mineral by the lead-ratio method.

The anthraxolite is a brilliant black carbon that has evidently been much sheared and is now plastered around rock fragments and quartz. It is penetrated by numerous veinlets consisting chiefly of quartz with lesser amounts of calcite and soft secondary minerals in the smaller fractures. Some metallic sulphides are present in the rocky portions. By crushing, small pieces of the anthraxolite can be picked out that appear to be perfectly pure, but even if the greatest care be exercised it is almost impossible to be certain that the fragments do not contain some very thin included veinlets of quartz or other minerals. For this reason it was impracticable to attempt to isolate a sufficient quantity of the absolutely pure material for analysis.

A 50 gram sample for analysis was obtained by crushing the best specimens on hand to about eighth-inch fragments and picking out visible quartz and other impurities without attempting any microscopic examination of individual fragments. The sample was burned in a muffle at low red heat and yielded a residue weighing 3.35 grams consisting chiefly of quartz and rock fragments along with a minor amount of fine brownish powder evidently representing the true ash of the mineral. The residue was sifted through several bolting cloths of increasing fineness of mesh so long as there appeared to be no danger of losing the fine powder. The powder that passed through the last cloth having apertures of about 0.25 mm. weighed 1.1893 grams and was used for analysis, though it still consisted chiefly of lime, quartz and other impurities. Due to an oversight this sample was not ignited to constant weight at a higher temperature and probably contained water and possibly CO_2. The analysis was made primarily to get an idea of the U, Th, R. E., and V content of the mineral, but as many of the major constituents were also roughly determined as was conveniently possible.

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[1] Published with the permission of the Director, Geological Survey of Canada, Department of Mines, Ottawa.

PORT ARTHUR ANTHRAXOLITE RESIDUE
(Per cent of Original Sample)

SiO_2	0.3696
Fe_2O_3	0.1150
Al_2O_3	0.0168
MnO	0.0166
CaO	1.3366
MgO	0.0128
NiO	0.0626
CoO	Traces
U_3O_8	0.0034
V_2O_5	0.0008
Th, R. E.	Not detected

In order to obtain an idea of the amount of true ash present in the analyzed residue, a sample of small fragments individually selected for apparent purity under the binocular microscope, was burned in a platinum crucible. Combustible gases came off and burned for several minutes but no tarry matter was deposited on the sides or lid of the crucible. The residue from 3.7678 g. taken, weighed 0.0182 g. but on examination under the binocular was found to contain grains of quartz and white partly sintered silicates. After carefully picking these out the residue weighed 0.0063 g. which may be considered as being still somewhat in excess of the true weight of the essential ash.

Thus it appears that the anthraxolite contains only about 0.16 per cent or less of essential ash. Relating this value to the ash analysis above, the essential ash should contain about 39 per cent NiO, 2 per cent U_3O_8 and 0.5 per cent V_2O_3. This nickel content seems high and in fact some may have come from sulphides, but a qualitative test on the 0.0063 g. residue showed that a large percentage of Ni is certainly present in the essential ash. Although no Th nor R. E. were found, it is possible that very small percentages might escape detection owing to the small amount of true ash present and the fact that a separate sample which would have been most favorable for their exact determination was not available.

From these results the mineral does not appear to be particularly favorable for an exact age determination by the lead-ratio method, because of the small percentage of true ash, the small percentage of U in the ash, and the difficulty of obtaining the true ash free from impurities. Nevertheless, it might be possible to produce a reasonably clean anthraxolite concentrate by tabling or flotation, in which case further investigation would be justified.

Carbon minerals containing nickel and uranium were recognized long ago in Sweden.[2]

The geological occurrence of the Port Arthur anthraxolite has been described[3] and mapped[4] by T. L. Tanton, who says

> "anthraxolite occurs in narrow veins at a few places in Port Arthur and environs. The largest known deposit is half a mile east of the Golf Club, southwest of Port Arthur, where in the central part of a banded vein of the silver-bearing type, anthraxolite occurs through an exposed length of 30 feet with an average width of 6 inches. Beyond the limits of Fort William and Port Arthur map-area many occurrences of anthraxolite are known in veins cutting the Gunflint formation. None of the occurrences is of sufficient size to be of commercial value as fuel." (*loc. cit.* p. 201.)

The anthraxolite-bearing veins belong to a rather widespread system of fault-veins cutting both Animikie sediments and intrusive diabase. The veins carry in various instances, one or more of the following minerals: native silver, argentite, galena, chalcopyrite, sphalerite and pyrite, besides gangue minerals such as quartz, calcite, fluorite and barite. In many instances more or less anthraxolite also is present and in a few veins, it, along with quartz and calcite, constitutes the main vein filling.

In view of the presence of uranium in the anthraxolite of these veins, it would appear that the native silver and argentite which occur in the same vein system might carry sufficient uranium to permit determination of the age by the helium-ratio method.

Dr. Tanton has also found small quantities of anthraxolite in the banded ferruginous chert of the Gunflint (iron) formation in the same map-area.

[2] Nordenskiöld, M., *Comptes Rendus*, vol. **CXVI,** pp. 677–678, 1893.

[3] *Geol. Surv. Can., Memoir* **167.**

[4] *Geol. Surv. Can., Map* **2141,** No. 198A.

NOTES AND NEWS

GROWTH OF STALACTITES

Lloyd W. Fisher, *Bates College.*

Several brief articles concerning the rate of formation of stalactites and stalagmites have appeared from time to time in various journals. The data here presented are the result of a continuous study of some calcareous deposits formed in an inspection tunnel of the Gulf Island Dam, Central Maine Power Company, on Androscoggin River, about five miles upstream from Lewiston, Maine.

The impounded water has a head of 52 feet. The tunnel at its lowest point is 65 feet below the pond level. The bed rock of the river is chiefly a limy schist cut by pegmatites. The river carries considerable sulphite obtained from the pulp mills along its banks.

A series of measurements were made on 28 stalactites growing from the concrete arches of the tunnel or from the offsets containing the sumps. The first study was made August 1, 1932. The average length of the stalactites was then 3.16 inches. Water was first impounded at Gulf Island, September, 1926. If the assumption is made that the stalactites began to form as soon as the water was impounded, the average rate of growth has been 0.53 of an inch per year.

On August 1, 1933, the stalactites were again measured. No increase was noted in 17 of the forms which had become dry sometime during the year. The remaining 11 stalactites showed an average increase of 0.70 of an inch. If the total length of the 11 growing stalactites is computed for a yearly average over the seven-year period of the dam's existence the rate is 0.66 of an inch.

A pipe two inches in diameter runs the entire length of the tunnel on the upstream wall. From this pipe 17 stalactites are forming. No measurements were made on these the first study period. Their growth is accordingly listed for seven years and the average growth per stalactite per year is 0.28 of an inch.

A comparison between the results of the present study and those of other writers is tabulated below.

	Longest Stalactite	Average Growth per Year
(1) Wilson Dam—Muscle Shoals, Florence, Alabama[1]	15.2″	3.04″
(2) Concrete Culvert[1]	3.5″	1.75″
(3) Coal Mine[1]	(min. av. 0.47″; max. av. 6.8″)	
(4) Lead Mine Timbers[1]	2.0″	0.8″
(5) Brick Arches in Fort Delaware, Del.[2]	5.0″	0.17″
(6) Brick Arches in Fort Pickens, Fla.[3]	10.0″	1.00″
(7) Roofs and walls, Fort Morgan, Ala.[4]	8.0″	0.14″
(8) From limestone railroad ballast[5]	12.5″	1.04″
(9) Gulf Island Dam		
a. stalactites on pipe	5.1″	0.28″
b. stalactites in arches (28) (on 7 year basis)	8.63″	0.53″
c. 11 of (b) now growing (1 year basis)	2.8″[6]	0.70″
d. 4 largest, Aug. 1, 1932	8.63″	0.95″
e. one stalactite[7]	11.50″	2.30″

No real correlation appears in the above taken as a whole. Stalactite growth in Fort Morgan and Fort Delaware is nearly at the same rate. Calcium carbonate in lime mortar supplied the material for the stalactites. An easily soluble limestone is represented in no. 8. The growths under nearly similar conditions are represented by nos. 1 and 9*e*, respectively. The head of water at these dams is respectively 90 feet and about 60 feet. W. M. Davis[8] says ". . . small differences of head beneath a peneplain will retard groundwater circulation and thus lessen its solvent power." Perhaps this explains in part the discrepancy between nos. 1 and 9*e*.

Several stalagmites deposited in Gulf Island Tunnel on an insulated pipe showed an average over 6 years of 0.25″ height and 0.36″ diameter of base. This growth compares rather favorably with 0.12″ and 0.21″, respectively, by von Steeg,[5] and 0.3″ and 4.0″, respectively, by Edwards.[6]

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[1] Johnston, W. M. Jr., Rate of growth of stalactites: *Sci.* (ns.), vol. **72,** p. 299, Sept. 19, 1930.

[2] Richards, Gragg, Growth of Stalactites: *Sci.* (ns.), vol. **73,** p. 393, April 10, 1931; and vol. **75,** p. 50, Jan. 8, 1932.

[3] Ellis, E. W., Concerning rate of formation of stalactites. *Sci.* (ns.) vol. **73,** p. 67, Jan. 16, 1931.

[4] Edwards, H. M., The growth of stalagmites. *Sci.* (ns.) vol. **76,** p. 368, Oct. 21, 1932.

[5] Von Steeg, Karl, Stalactites from railroad bridge, *Boston Transcript*, March 12, 1932.

[6] Represents greatest increase noted in the elapsed year.

Wall coatings at Gulf Island are distributed uniformly on both upstream and downstream sides of the tunnel averaging one inch in thickness at right angles to the walls. Ridges of calcium carbonate extend from the junctions of the arches and are one inch thick and 1½″ to 2½″ wide.

A recording thermometer was installed in the tunnel from July 28, to August 4, 1933. The temperature of the tunnel was uniformly 62 degrees for 4½ days and between 64 and 62 for 2½ days. Outside temperatures during the same period varied from 62 to 86. The water in the tunnel does not freeze in winter despite zero temperatures outside. Atmospheric pressure inside the tunnel was determined by an aneroid barometer on six different occasions. No noticeable differences in tunnel and outside pressure was noted.

The writer expresses his thanks to Leon Ladd, Superintendent of Gulf Island Dam for permitting and aiding the study, and for protecting the measured stalactites from curious tunnel visitors.

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[7] Broken off on Oct. 1, 1931, during inspection trip.

[8] Davis, W. M., Origin of limestone caverns; *Sci.* (ns.), vol. **73**, p. 329, Mar. 27 1931.

PARAGONITE FROM PIZZO FORNO, TICINO, SWITZERLAND

R. B. McCormick, *University of Wisconsin*.

A "paragonite" schist from the type locality for paragonite,[1] Pizzo Forno, near Faido, Ticino, Switzerland was donated by Ward's Natural Science Establishment and studied to determine the properties of paragonite.

In a hand specimen the paragonite is a white, flaky mica with a vitreous to pearly luster, forming the ground mass for small crystals of cyanite and staurolite. A portion of the rock was ground up and the constituent minerals separated by heavy liquid gravity methods. A variation in specific gravity in the paragonite from 2.82 to 2.90 was found and the cause determined by microscope methods as being due to minute inclusions of cyanite, staurolite and an opaque mineral, probably magnetite.

The gravity separates of paragonite were *x*-rayed by the powder method and the patterns thus obtained showed no apparent variation from a standard muscovite pattern. Measurements of the indices of refraction on grains from different gravity separates by means of the Emmons double variation apparatus[2] and Emmons improved universal stage[3] usually range less than ±.001 for a given ray, indicating the paragonite to be of uniform chemical composition despite the variation in specific gravity.

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[1] Dana, E. S., Textbook of Mineralogy, 4th ed., p. 661.

The optical data for the paragonite are as follows:

(−)	$2V=42°$
	Na light
N_g	1.6020
N_m	1.5960
N_p	1.5635
N_g-N_p	0.0385

A partial chemical analysis for the percentages of K_2O and Na_2O present in the mica was obtained through the courtesy of Dr. N. J. Volk. This analysis showed 4.6 per cent K_2O and 1.77 per cent Na_2O. Calculation on the basis of molecular percentages results in 63.1 per cent K_2O and 36.9 per cent Na_2O or a ratio of two molecules of muscovite to one of paragonite. Since the chemical analysis was made only for these two oxides, it is impossible to state what molecules of the muscovite system are present, or to make definite statements as to the effect of the paragonite molecule on the optical properties of muscovite. In this paragonite, however, the refractive indices are higher and the optic angle somewhat less than the values for "pure muscovite" given by Winchell.[4]

CONCLUSION

It has been shown that the so called paragonite schist of Pizzo Forno, Switzerland, is primarily a muscovite schist containing about 37 per cent of the paragonite molecule. Paragonite as a distinct mineral has not been found in nature, indicating that it probably is an unstable molecule of the mica group.

The writer is indebted to Mr. G. L. English of Ward's Natural Science Establishment for the specimen, to Professors A. N. Winchell and R. C. Emmons for helpful criticisms and suggestions, and to Dr. N. J. Volk for a partial chemical analysis of the mineral.

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[2] Emmons, R. C., *Am. Min.*, vol. **14**, p. 414, 1929.

[3] Emmons, R. C., *Am. Min.*, vol. **14**, p. 441, 1929.

[4] Winchell, A. N., Elements of Optical Mineralogy, Pt. II. p. 267.

HEMATITE AT CAPE YORK, GREENLAND

Ralph L. Belknap, *University of Michigan.*

One of the difficulties encountered in mapping in northern Greenland is due to the fact that there may be a decided change in the declination within a relatively small area. This is especially true in the Cape York area.

The old sea charts indicate a declination at Cape York of over 95°. In the summer of 1932 the author made an azimuth determination in connection with some work being done on top of Cape York. As a result of several determinations it was found that the declination varied between 68° and 72°—a difference of about 25° from that given on the charts.

The explanation of this was believed to have been due to the presence in the moraines of small boulders of specular hematite, nartite in quartz, and quartzite with thin seams of specular hematite—a rock somewhat similar to the jaspilite of the Lake Superior district.

While only a few such boulders were found in the moraines on Cape York itself this must have been brought down from the higher land farther north along Death Fjord. The occurrence of such a deposit farther north in the direction of the shore line of this fjord, but not too far removed, would account for the difference between the value shown on the charts and the value as determined by astronomic observations at Cape York.

BOOK REVIEW

KRISTALLCHEMIE. Dr. O. Hassell. Pp. 114+viii, figs. 8. Verlag von Theodor Steinkopff, *Dresden* and *Leipzig*, **1934**. Price, geheftet RM. 9, gebunden RM. 10.

Textbooks on the subject of crystallochemistry are not numerous and this one which attempts to unify this subject as well as to include the newer views which have developed recently is very desirable.

The text should appeal to those who are interested in a brief survey of the field of crystallochemistry and who are especially interested in having at hand a collective reference work.

The contents presuppose a general knowledge of the more common types of crystal structure. After a short resumé of the history of crystallochemistry the author enters into a description of the effective radii of atoms and ions in crystals. This is followed by the Goldschmidt derivation of ionic and atomic radii and the commensurability of lattices, together with a discussion of the effects of polarization.

Summaries of the crystallochemistry of some simple compounds, the silicates. intermetallic compounds and molecular compounds are included. Discussions of the work of Pauling, and Zachariasen are given, and sections on the significance of Wernerian complex compounds, the rotation of the molecule or the radical group in the crystal lattice, etc., bring the book well up-to-date.

George T. Faust

PROCEEDINGS OF SOCIETIES

NEW YORK MINERALOGICAL CLUB

Minutes of the November Meeting, 1933

A regular meeting of the New York Mineralogical Club was held on Wednesday evening, November 15th, 1933, at The American Museum of Natural History. The meeting was called to order by President Alfred C. Hawkins. The attendance was 100.

Mr. Allen read a reply from Professor Edward Salisbury Dana to his notification of honorary membership in the Club, which he was pleased to accept. Mr. James F. Morton reported on the Club Excursion which he led on Election Day, November 7th, 1933, to the Paterson, N.J., quarries. He reported on the following list of minerals collected that day:

West Paterson Quarry:—Fifteen minerals including apophyllite, aragonite, calcite, chabazite, chlorite, datolite, deweylite, heulandite, laumontite, pectolite, prehnite, quartz including a fine amethyst, thaumasite, opal, and hyalite.

Prospect Park Quarry:—Eleven minerals including calcite, chlorite, chrysocolla, datolite, hematite, pectolite, prehnite, quartz, serpentine, opal, and hyalite.

President Hawkins then presented the speaker of the evening, Mr. Samuel George Gordon, Associate Curator of the Department of Mineralogy of the Academy of Natural Sciences of Philadelphia, who addressed the Club on "Fluorescent Minerals" and demonstrated fluorescence by means of the iron arc as a source of ultra-violet light. A good opportunity was presented to compare the effects of the Nico lamp with the iron arc light, Mr. Grenzig also provided a box containing a battery of argon glow lamps so that three of the methods of obtaining fluorescence were demonstrated at the same time.

Daniel T. O'Connell, *Secretary*

Minutes of the December Meeting, 1933

A regular meeting of the New York Mineralogical Club was held at The American Museum of Natural History on the evening of Wednesday, December 20th, 1933. The meeting was called to order by President Alfred C. Hawkins. The attendance was 33.

Mr. Stanton announced the death of Ernest Shernikow in San Francisco on Saturday, December 16th. Mr. Shernikow was one of the charter members of the Club and once had served as President.

President Hawkins described some of his recent researches dealing with the glauconitic marls of New Jersey. The lower member was found to contain in addition to quartz and glauconite some small gypsum crystals.

President Hawkins then introduced Mr. Martin L. Ehrmann, who spoke on the subject of "Kunzite." Mr. Ehrmann described what he found when he purchased the collections of the late Dr. Kunz. There were some remarkable mineral specimens including four kunzite crystals, the largest one weighing 72 ounces. This was the largest crystal of kunzite ever found, and was the most beautiful, clearest, and best in color, but it was not a perfect crystal. A smaller specimen weighing 36 ounces was almost a perfect crystal. In the collection were several 10 carat diamonds besides smaller ones and a large number of semi-precious stones. A collection of meteorites was also noteworthy which is now owned by Mr. Ernest Weidhaas. Mr. Ehrman related the history of kunzite, first found on the 8th of June, 1901, by Fred M. Sickler of Pala, California. Professor Charles Baskerville of the College of the City of New York who made a detailed analysis of the mineral named it kunzite.

DANIEL T. O'CONNELL, *Secretary*

Minutes of the January Meeting, 1934

A regular meeting of The New York Mineralogical Club was held on the evening of January 17th, 1934, at The American Museum of Natural History. President Alfred C. Hawkins called the meeting to order at 8:15 P.M. The attendance was 85.

The paper read at the December meeting by Mr. Martin L. Ehrmann, on "Kunzite," was ordered submitted to the Executive Committee to determine the advisability and method of its publication for distribution to the membership.

Mr. James F. Morton reported the occurrence of sulphur crystals in pyrite, found in a clay pit at Sayreville, near New Brunswick, N. J.

The speaker of the evening, Professor Joseph Edmund Woodman, Professor of Geology at New York University, was introduced by President Hawkins. His subject was "Geology 'Round the World with the First Floating University." Professor Woodman described the volcanoes, harbors, and other details of geologic interest on the world cruise of the "University." His talk was illustrated with slides.

DANIEL T. O'CONNELL, *Secretary*

Minutes of the February Meeting, 1934

A regular meeting of the New York Mineralogical Club was held at The American Museum of Natural History on the evening of February 21st, 1934, with an attendance of 46. The meeting was called to order by President Alfred C. Hawkins.

A letter of acknowledgment from Mrs. Shernikow was read in reply to the expression of sympathy from the Club on the occasion of the death of our past President, Ernest Shernikow.

The certificate of honorary membership to be presented to Professor Edward Salisbury Dana was reported completed and exhibited by the committee.

President Hawkins introduced the speaker of the evening, Dr. Benjamin L. Miller, Professor of Geology at Lehigh University, Bethlehem, Pa., who addressed the club on the subject of "The Origin, Characteristics, and Distribution of Graphite."

Professor Miller traced the history of graphite beginning with the ancients, who used it in pottery and paintings, through the time of the alchemists, who used it in their preparations to the modern use in pencils. In discussing the grades of graphite, he pointed out that although the trade speaks of an amorphous graphite and a crystalline graphite, and the United States places a lower tariff on so-called amorphous graphite, all graphite is crystalline and the dull appearance of the so-called amorphous graphite is due to the small size of the crystals.

In discussing the origin of graphite, Professor Miller stated that the presence of graphite in a rock is not necessarily an indication of the existence of life, especially when found in igneous rocks or in contact zones near them.

A discussion by the members followed, on the possible inorganic origin of graphite. A vote of thanks was tendered Professor Miller at the conclusion of his address.

Daniel T. O'Connell, *Secretary*

Minutes of the March Meeting, 1934

A regular meeting of the New York Mineralogical Club was held at The American Museum of Natural History on Wednesday evening, March 31st, 1934. The attendance was 86. The meeting was called to order by First Vice-President George E. Ashby.

The Nominating Committee reported the following nominations for the officers of the Club for the year 1934–35.

President	Mr. Gilman S. Stanton
First Vice-President	Dr. Horace R. Blank
Second Vice-President:	Mr. Stephen Varni
Secretary:	Dr. Daniel T. O'Connell
Treasurer:	Miss Catherine Schroder

Correspondence between Mr. Frederick I. Allen and Professor Edward Salisbury Dana was read by Mr. Stanton, in which Professor Dana accepted the invitation extended him to meet with the Club on the occasion of the presentation to him of the engrossed certificate of Honorary Membership in the Club.

Chairman Ashby then introduced Professor Alexander Hamilton Phillips, Professor of Geology and Mineralogy, Princeton University, who described his experiences in South Africa at the 15th International Geological Congress and subsequent travels under the title, "Collecting Minerals in South Africa." His travels included visits to the Victoria Falls, Table Mountain, the Kimberly Pit, famous for diamonds, the Vaal River diamond deposits, Johannesburg and the conglomerate gold ore at Robinson Deep, 6600 feet deep, the salt pans of Karoo, the Morenski Reef Platinum deposit, asbestos and chromite mines of Northern Rhodesia, and the gold mines of Southern Rhodesia.

Captain Thomas I. Miller exhibited an apparatus for detecting fluorescence, based on a design by Stokes making use of a cobalt glass and a yellow glass. Light passes through the cobalt glass and then falls on the specimens being tested, which are viewed through the yellow glass.

Daniel T. O'Connell, *Secretary*

Correction

In the June issue, page 256, line 19, should read "cleavage" instead of "twin." Line 37, omit the word "counter" before clockwise.